A STUDY OF SUPPLEMENTAL SAFETY SYSTEMS WITH WHISTLE BANS AT HIGHWAY-RAIL GRADE CROSSINGS: THE SPOKANE EXPERIENCE

DATA ANALYSIS

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Acknowledgments

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1. INTRODUCTION

In 1996, Spokane County, Washington, the Washington State Utilities and Transportation Commission along with the Burlington Northern Sante Fe Railroad (BNSF) entered into an agreement to conduct a three phase study to determine whether non-mountable curbs (median barriers) would be an effective supplemental safety measure as a replacement for train horns. Each phase was to last 4 months with video cameras being used to record driver behavior. In actuality, each phase lasted 115 days. A fourth phase was added to consist of monitoring for a period of one week per month for three months and one week each quarter thereafter.

Data collection and analysis in the first three phases and the first part of the fourth phase was carried out by the Public Works Department, Division of Engineering of Spokane County. Data analysis for the latter part of phase four is being accomplished by Applied System Technologies, Inc. (ASTI)

This study is the first one of its kind to incorporate video monitoring with quiet zones**.**

The purpose of this study was to determine:

1. Whether, and to what extent, installing a median barrier at the BNSF railroad crossing at University Road in Spokane County has served to reduce the number of crossing violations at that location, and

2. What impact the subsequent implementation of a whistle ban has had upon the rate at which violations occur.

2. THE STUDY

The study is conducted in four phases with driver behavior data being collected through the use of video monitoring equipment at the crossing.

2.1 Phase 1 - Baseline

During this phase, which lasted from June 17, 1996 through October 30, 1996, there was neither a median barrier nor a whistle ban in place.

2.2 Phase 2 - Median Barrier Only

During this phase, which lasted from November 28, 1996 through May 17, 1997, there was a median barrier but no whistle ban.

2.3 Phase 3 - Median Barrier Plus Whistle Ban, Continuous Monitoring

During this phase, which lasted from December 29, 1997 through March 21, 1998, there was both a median barrier and a whistle ban. Despite the ban, however, some sounding of whistles may have occurred. Resident witnesses reported frequent soundings of the train horn. A dosimeter placed at this location expressly to monitor possible whistle soundings revealed 231 noise spikes, in all of Phase 3, that were of sufficient amplitude to indicate a whistle may have sounded. A "spike" was defined as any reading, measured at the dosimeter microphone, in excess of 100 db. The dosimeter microphone, it should be noted, was located in a cabinet, not in the open.

2.4 Phase 4 - Median Barrier Plus Whistle Ban, Periodic Monitoring

During each of the months of July, August, and September 1998, and on a quarterly basis thereafter, with both the median barrier and whistle ban in effect, a designated period of time, ranging from four to seven days, was set aside for video and audio monitoring purposes. The specific dates were as follows:

- July 7-10, 1998
- August 10-16, 1998
- September 14-20, 1998

This represents a total of eighteen days.

After the photographic monitoring period in September, Phase 4 was continued to include additional monitoring for one continuous week during each quarter beginning with December of 1998. The first period was December 15 through 21, 1998, and the second period was March 21 through 27 of 99. The tapes from the week in December have been briefly reviewed but not analyzed and the tapes from March are not available at the writing of this report. Both tapes will be reviewed and the data analyzed in a subsequent follow-on report.

3. DATA ANALYSIS

By reviewing the video taken at this location, Christopher Reich of the Spokane County Division of Engineering and Roads was able to identify the following important items of information:

1. Gate Activations - The number of gate activations that had taken place, subdivided according to whether or not a train was present. (Note: Not all gate activations resulted from the approach of a train).

2. Incidents - The number of occasions on which one or more violations of the following form were observed: a vehicle or a pedestrian going through the lights after the activation has begun, a vehicle or a pedestrian going around a gate, or a vehicle hitting a gate. Again this information was subdivided according to whether or not a train was present.

Both of these items of information, documented in a series of reports issued by Spokane County are briefly summarized below in Table 1.

Table 1
Number of Gate Activations and Incidents,
With and Without a Train Present

	Phase 1	Phase 2	Phase 3	Phase 4
No. of Gate Activations				
Train present	4,556	4,924	5,003	680
No train present	31	155	117	18
No. of Incidents				
Train present	1,565	61	66	14
No train present	419	5	9	7

The first point to note is that there is no material difference from one phase to the next in the number of gate activations per day. In Phase 1, which lasted 115 days, there were 4,587 activations in all, for an average of 39.9 per day. In Phases 2 and 3, each of which also lasted 115 days, the averages were slightly higher – 44.4 and 44.8 respectively – while in Phase 4, a total of 18 days of monitoring, the average was 38.8.

These numbers reflect a relative stability in the rate at which gate activations took place. Given this stability, a useful statistic for measuring the impact of adding a median barrier (Phase 2) followed by a whistle ban (Phases 3 and 4) is the number of incidents per 100 gate activations. Those numbers, based on the data contained in Table 1, are presented below in Table 2.

Table 2
Number of Incidents Per 100 Gate Activations,
With and Without a Train Present

	Phase 1	Phase 2	Phase 3	Phase 4
Number of incidents per 100 gate activations:				
Train present	34.4	1.2	1.3	2.1
No train present	1,351.6	3.2	7.7	38.9

Incidents are clearly more common in situations where there is no train present - presumably because on such occasions they tend to be clustered, with a number of vehicles proceeding across the intersection at a time, each vehicle counting as a separate incident. In Phase 4, for example, the seven incidents in Table 1 for which there was no train present all took place at the same time, the result of a single malfunctioning gate. Given that there was no train present at the time, these are incidents in name only, i.e., have no long-term impact in terms of safety. The variation in these numbers, shown in the bottom line of Table 2 is therefore of no real consequence. The only numbers that really matter are those involving situations in which a train WAS present.
Those numbers show the following:

a. A sharp decline in incident rate between Phases 1 and 2, from roughly one incident in every three gate activations (34.4 per 100) to roughly one in every eighty (1.2 per 100).

b. Essentially no change between Phases 2 and 3, followed by a minor increase in Phase 4. The latter increase is almost, but not quite, statistically significant.

Before any conclusions can be reached, however, based on these numbers, it is important to refine the analysis by taking into account differences in the volume of automotive traffic from one phase to the next. As it turns out, the only phase that differed materially from the others in terms of average annual daily traffic (AADT) was Phase 1. The relevant numbers are shown in Table 3.

Table 3
Average Annual Daily Traffic

Phase 1 AADT	3,831
Phase 2 AADT	1,918
Phase 3 AADT	1,991
Phase 4 AADT*	

* No count of AADT in Phase 4 has been conducted as yet. The reports issued by Spokane County assume the same AADT as Phase 3.

The 2-to-1 decline in volume between Phases 1 and 2 naturally biases any direct comparison of the incident rates in those phases. It would be reasonable, however, to assume that the incident rate in any given phase is directly proportional to the volume of traffic in that phase. Operating on that assumption, it is a simple matter to normalize the incident rates in each of the phases so that they reflect the same hypothetical volume of traffic throughout. Table 4 shows what the Table 2 incident rates would be, given a train was present, if every phase had the same, assumed AADT of 1000 vehicles.

Table 4
Number of Incidents Per 100 Gate Activations
With Train Present per 1000 vehicles

Phase 1	8.97
Phase 2	0.65
Phase 3	0.66
Phase 4	1.03

These numbers, it will be seen, are simply the incident rates shown in Table 2 divided by 3.831 in the case of Phase 1, 1.918 in the case of Phase 2, and 1.991 in the case of Phases 3 and 4, thus placing all phases on an equal footing in terms of the rate of daily traffic.

While the difference in incident rates between Phases 1 and 2 is seen to be somewhat reduced in Table 4 compared to what it was in Table 2, the difference remains impressively large - roughly 14 to 1 - reflecting the tremendous reduction in violations resulting from installation of a median barrier. The differences between Phases 2 and 3, as well as between 2 and 4, remain essentially as noted earlier. The small magnitude of these differences, coupled with the fact that they are statistically insignificant, points to the possibility that the whistle ban may not have had much of an impact.

Any conclusions concerning the whistle ban need to be tempered, however, by the following consideration: there is reason to believe the ban may not have been fully observed in Phase 3, and possibly in Phase 4 as well. As noted earlier, there were a number of occasions in each of those phases (231 in Phase 3, 4 in Phase 4) in which unusual noise spikes were observed.. If one assumes that each of those occasions represented a train whistle and that the sounding of a train whistle MAY prevent a motorist or pedestrian from committing a violation that might otherwise have occurred, the number of incidents reported in Phases 3 and 4 may have been understated.

In the absence of further research, there is no way of knowing what the relationship among these factors might be but if one assumes that 10 percent of the 231 suspected whistle soundings in Phase 3 served to prevent a violation from taking place, it follows that the observed number of incidents in that phase in which a train was present, was understated by 23 (10% of 231). Adding this number to the number reported in Table 1 (66) would cause the corresponding incident rate shown in Table 4 to increase from 0.66 to 0.89. The difference with respect to Phase 2 would now be statistically significant, but still minor compared to the major improvement observed between Phases 1 and 2.

Compliance with the whistle ban seems to have improved between Phase 3 and 4. Whereas Phase 3 had a total of 231 ultra-high audio readings within the space of 115 days, there were only four such readings in the 18 days of Phase 4. This difference in the rate at which extreme audio peaks were observed - from roughly two per day in Phase 3 to one every 4 ½ days in Phase 4- is statistically significant.

Of the four apparent whistle soundings in Phase 4, even if only ONE of them served to prevent an incident from happening, adding that one event to the previous total of 14 shown in Table 1 would suffice to create a difference between the incident rates in Phases 2 and 4 that would now be statistically significant. That is to say, only one more hypothetical incident would be needed to permit one to conclude that the whistle ban, had it been more scrupulously observed, would have resulted in an increase in incident rate in Phase 4 compared to Phase 2. Again, however, such an increase, though statistically significant, would be distinctly minor compared to the major reduction achieved in Phase 2.

Additional Analysis focusing on Incident Severity

So far, the analysis has examined the issue of "violation" only. Not all violations, however, have the same impact. In point of fact, some are more serious than others – are more likely to result, if not today then sometime in the future, in human or property damage. Clearly, violations in which a vehicle (or pedestrian) breaches the unoccupied track but then stops or reverses direction before reaching the occupied track, are less serious than those in which the occupied track was breached as well. In studying the likely long-term impact of the median barrier and/or whistle ban at this location, it would be useful to provide such a distinction, i.e., to distinguish between violations that present the ultimate threat of an accident and those that do not. One way of doing this would be to disaggregate the number previously presented to reflect only those incidents in which:

(A) the occupied track was violated, and

(B) a train was present

To reflect this distinction, the data presented earlier were further subdivided as shown in Table 5.

Table 5.
Number of Gate Activations and Incidents
Involving Breaches of the Occupied Track

	Phase 1	Phase 2	Phase 3	Phase 4
Number of activations in which a train was present (from Table 1)	4,556	4,924	5,003	680
Associated number of incidents in which it was the OCCUPIED track that was breached	882	22	30	6

Assuming, as before, the same hypothetical AADT of 1,000 vehicles in all four phases, the normalized incident rates for Phases 1 through 4 are seen in Table 6.

Table 6
Number of Incidents Involving the Occupied Track
Per 100 Gate activations per 1000 vehicles

Phase 1	5.05
Phase 2	0.23
Phase 3	0.30
Phase 4	0.44

Comparing these numbers to those in Table 4, one notes that limiting the analysis to violations involving the occupied the occupied track has had the effect of accentuating the observed differences in incident rate from one phase to the next. The difference between Phases 2 and 3 is now greater than it was before, although it remains statistically insignificant. The difference between Phases 2 and 4, expressed as a ratio, has also widened and is now statistically significant although, as before, distinctly minor compared to the major improvement noted in Phase 2.

A final observation with respect to incident severity deals with the matter of "time before impact", defined as the number of seconds between when a vehicle crosses the occupied track and when the train encroaches on the roadway. In Phase 1, before the median barrier was installed, there were 41 incidents in which the time before impact, as defined, was ten seconds or less, eleven in which it was five seconds or less.

In Phases 2 and 3, there were no such "near misses"; in each of these phases, the shortest time before impact involved in any single incident was 15 seconds, further evidence of the heightened safety associated with those phases.

4. FINDINGS AND CONCLUSIONS

The preceding results are briefly summarized as follows:

A. Effect of Median Barrier

Installation of a median barrier at this location clearly has had a profound beneficial effect. Considering only violations involving the occupied track when a train was present (Table 6), a greater than 20-10-1 reduction in incident rate was observed between Phases 1 and 2. The corresponding reduction in the case of violations involving either the occupied OR unoccupied track (Table 4) was roughly 14 to 1.

b. Effect of the Whistle Ban

Imposition of a whistle ban seems to have increased the incident rate slightly. In Phrase 3, when the ban may not have been fully observed, the increase was statistically insignificant; in Phase 4, when there is reason to believe the ban was more scrupulously observed, the increase rose to the level of statistical significance in the case of violations involving the occupied track (Table 6) but remained statistically insignificant in the case of violations involving either the occupied OR unoccupied track (Table 4).